

REPORT DOCUMENTATION PAGE

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MEMORANDUM FOR PRS (In-House Publication)

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11 June 2001

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2001-134**
Blanski, Rusty; Phillips, Shawn; Lee, Andre, "The Preparation and Properties of Polymer/Nanoparticle
Blends Using POSSTM" (VuGraphs)

2001 International Symposium on Nanocomposites
(Chicago, IL 25-27 June 2001)(Deadline: 24 June 2001)

(Statement A)

The Preparation and Properties of Polymer/Nanoparticle Blends Using POSSTM

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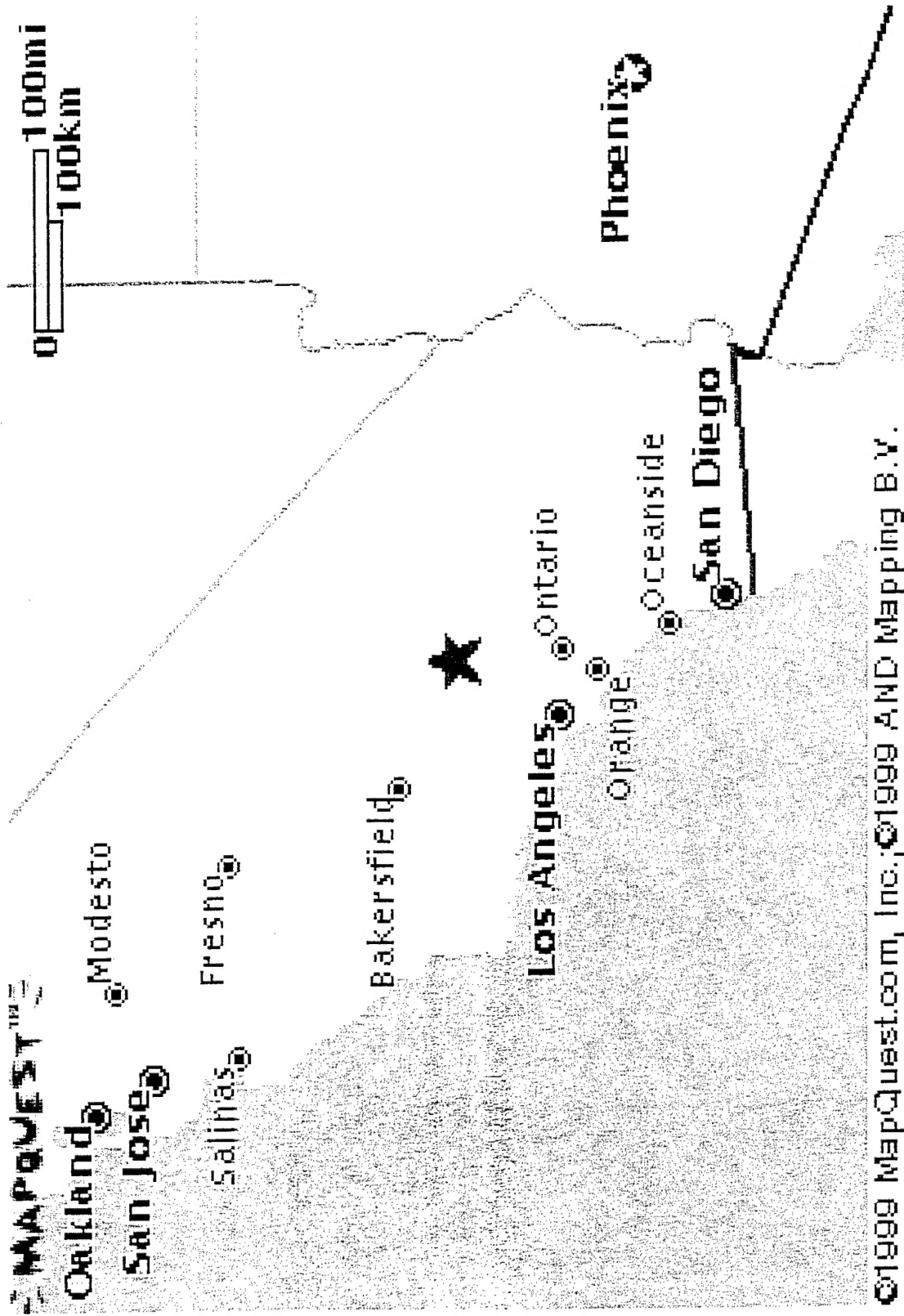
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Air Force Research Laboratory

Located ~ 100 miles from LA





POSS/Polymer Blends



- **GOAL:** We are looking to increase the use temperatures of polymers by blending in Polyhedral Oligo^{meric (and a space)}sil^{ses}quioxanes (POSS)
- Several polymers were looked into as candidates for blending: Polyethylene, Polystyrene, Polycarbonate, and Styrene-Butadiene Rubber



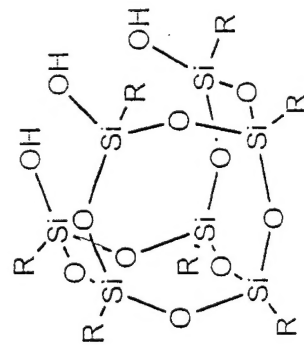
Why Use Blendables?



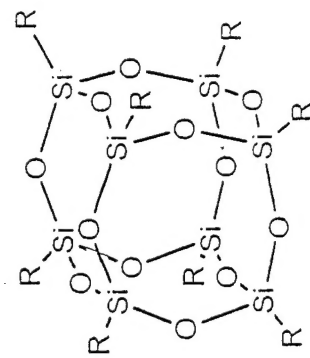
- Easier to tailor the organic side groups of the POSS molecule to give a polymer-soluble species
- Simple blending techniques can be used instead of copolymerization with reactive POSS monomers
- Potential Drop-in molecular modifier without requiring expensive replacement of processing equipment



POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis



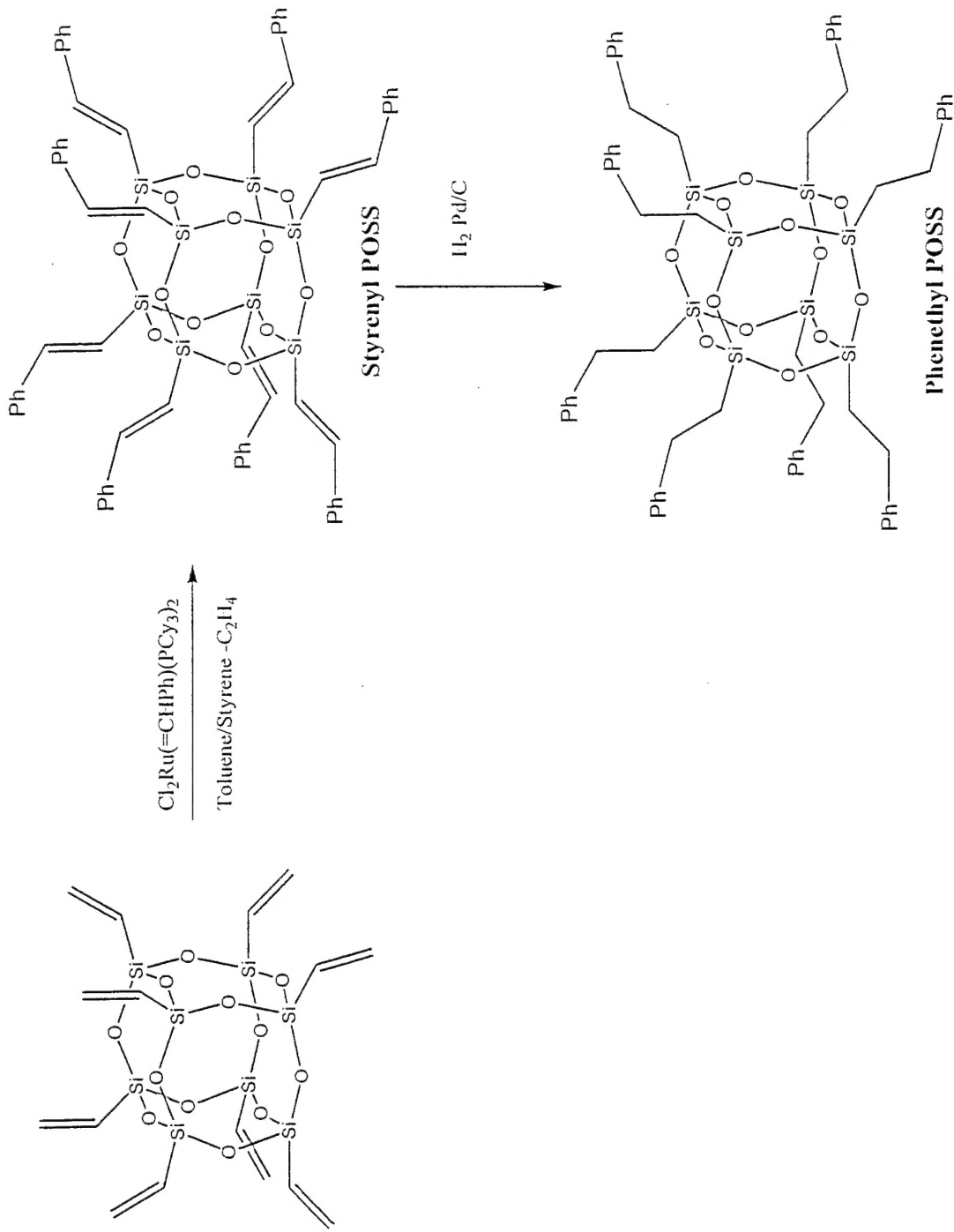
R = cyclopentyl
vinyl



R = cyclopentyl
vinyl

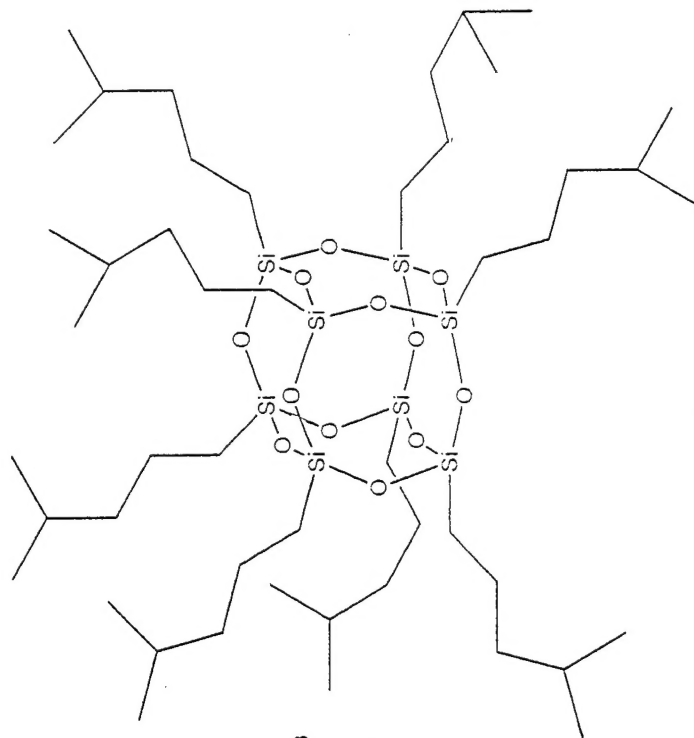


POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis



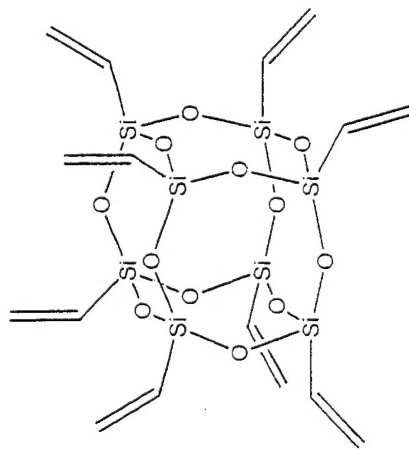


POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis



4-MP POSS

1. $\text{Cl}_2\text{Ru}(=\text{CHPh})(\text{PCy}_3)_3$
4-Methylpentene, $-\text{C}_2\text{H}_4$
2. Pd/C H_2 500 PSI

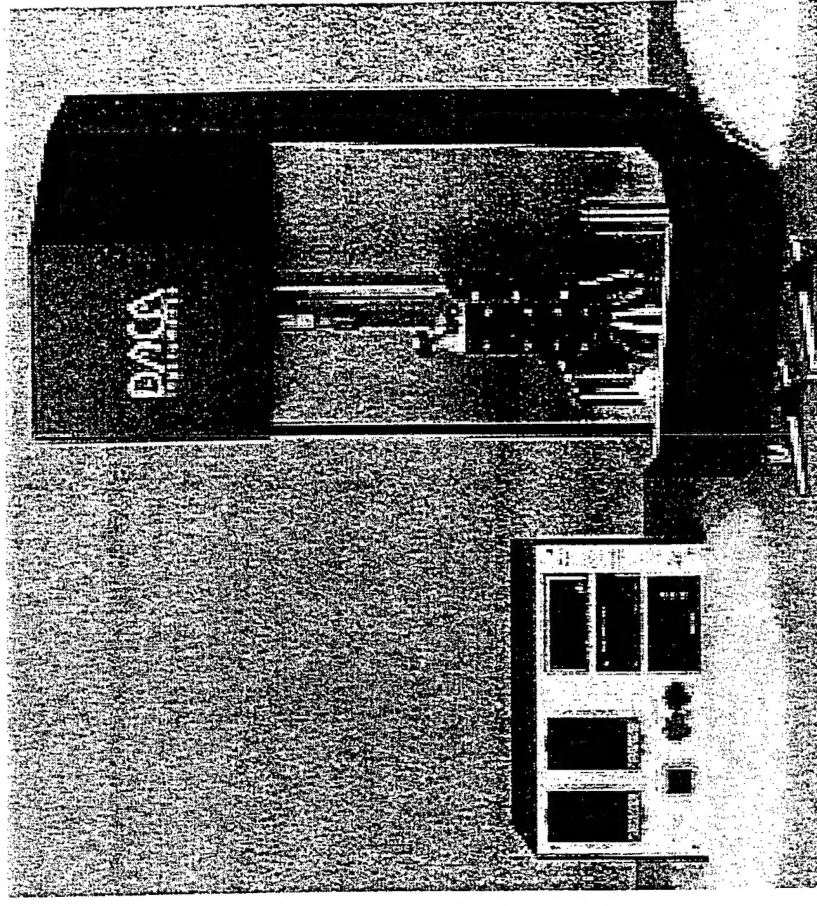




Preparation of Polymer-POSS Blends



- Traditional Processing
- Place Polystyrene in Extruder
- Add POSS
- Blend 2-5 Minutes
- Use a DACA for small scale (4 g)

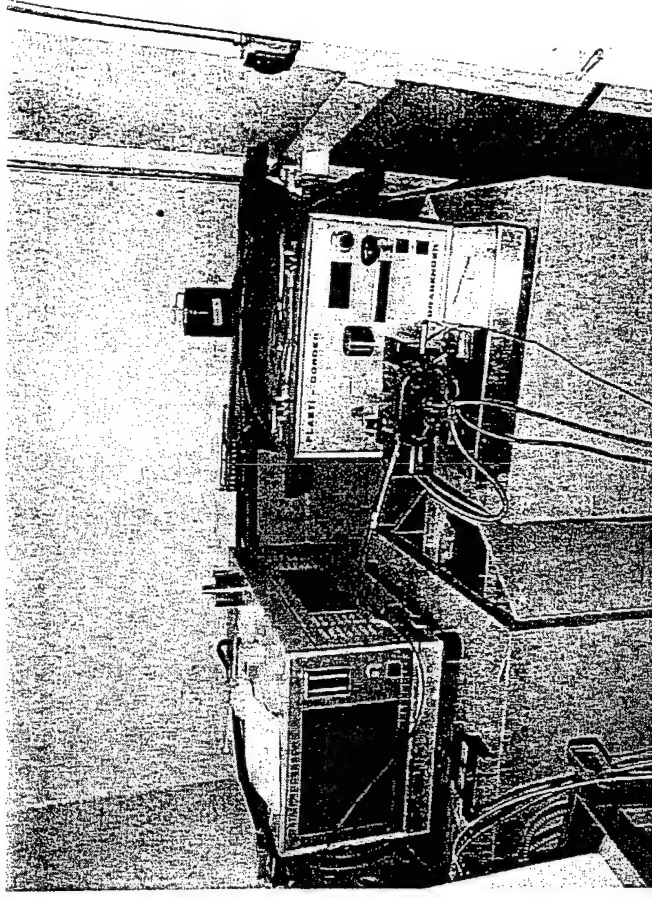




Preparation of Polymer-POSS Blends



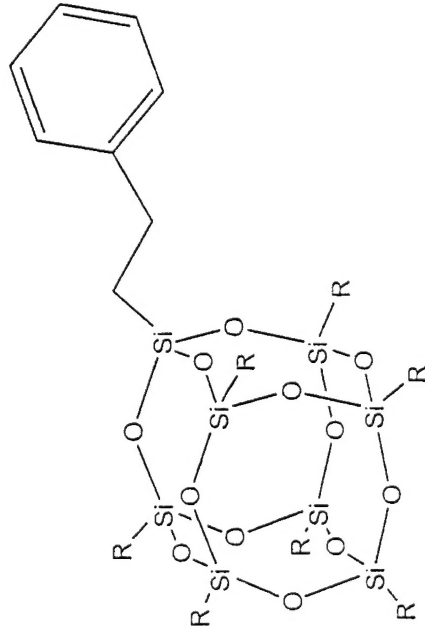
- Traditional Processing:
- Brabender Mixer
- Place Polystyrene in Mixer at temperature
- Add POSS
- Blend 5-10 Minutes
- Grind
- Press into disks/extrude/injection mold



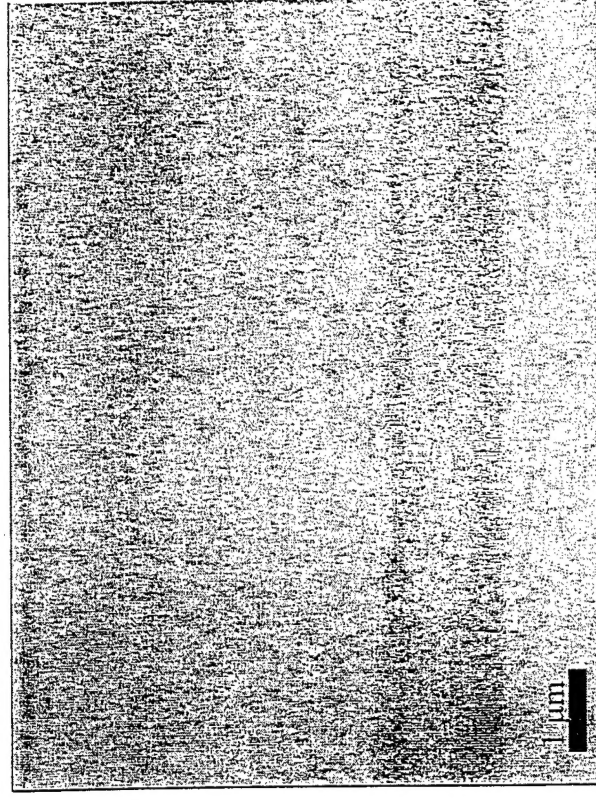


Miscibility of POSS

50 wt % Phenethyl₈T₈ in 2 million mol. wt. Polystyrene



R = Phenethyl



← Are there supposed to be black dots on this?

- Demonstrated Complete Miscibility
- Grey domains represent miscible POSS/polystyrene
- Black dots are POSS crystallites (<100 POSS molecules)
- 30% increase in surface hardness observed



POSS-Polymer Blends

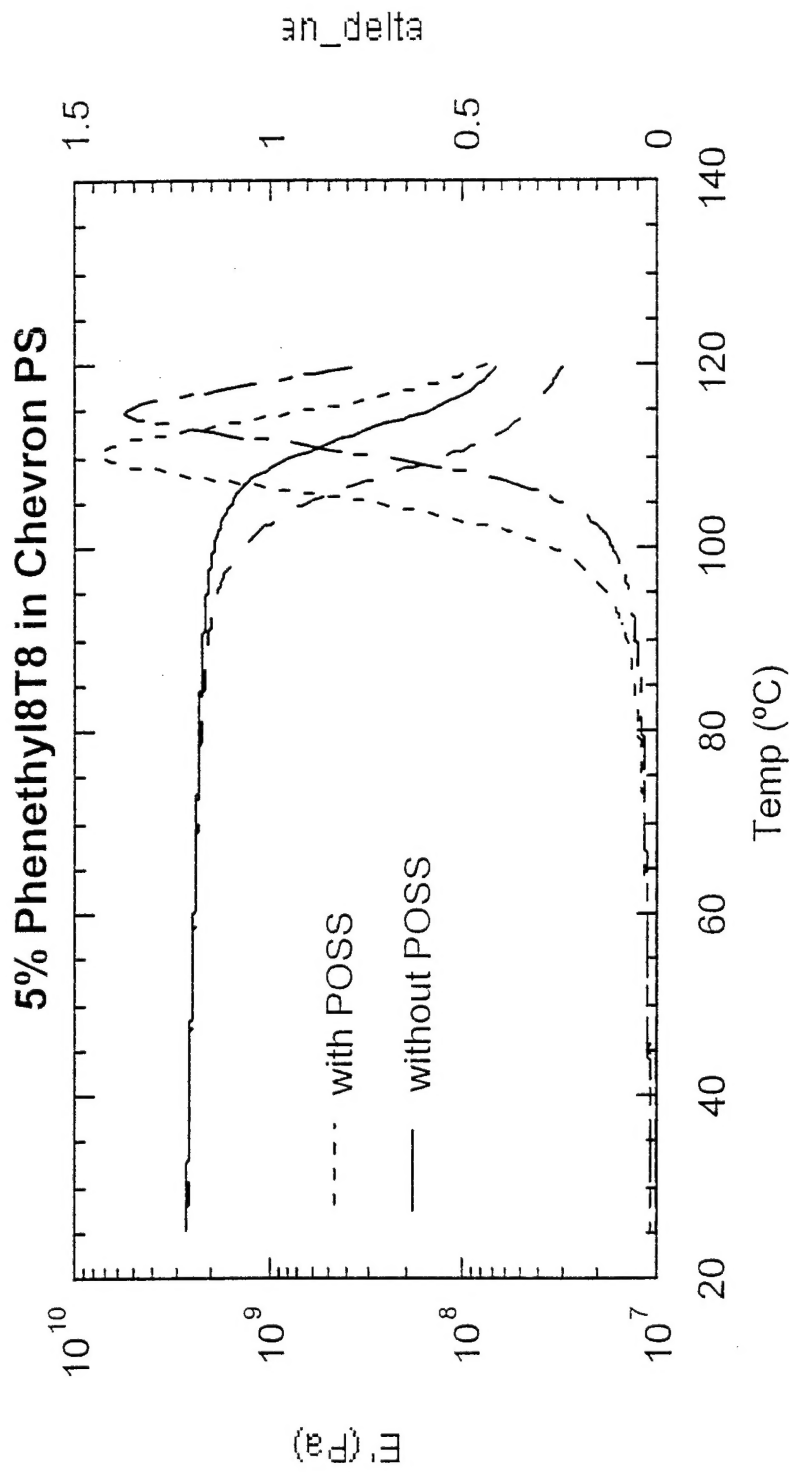


Selected Data for POSS-Polymer Blends

Resin	POSS compound	Processing Temp. °C	Appearance
Polystyrene	Phenethyl ₈ T ₈	177	Clear
BPA polycarbonate	Phenethyl ₈ T ₈	300	Clear
SB Rubber	Phenethyl ₈ T ₈	100	Clear
HDPE	Octyl ₈ T ₈	120	Cloudy
HDPE	4-MP ₈ T ₈ (2)	120	Cloudy



Addition of POSS into PS



No Change in modulus at ambient Temperatures
Small Change in T_g observed



Conclusions



- POSS can be blended and dispersed into many polymers
- The organic side groups on the POSS molecule are extremely important in determining the solubility of the POSS in polymers
- The addition of the more soluble Styrenyl POSS into styrene leads to an increase in surface hardness without adversely affecting polymer properties
- POSS can be thought of as functionalized silicas with the side groups acting as solubility enhancers